Shelf And Slope Sediment Transport In Strataform

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LONG-TERM GOALS

STRATAFORM is a multi-disciplinary, multi-investigator program designed to advance our understanding of the development of stratigraphic sequences on continental shelves and slopes. One of the major components of this coordinated program has focussed on investigating active sedimentary processes that lead to the formation and modification of seafloor deposits. Field experiments to evaluate the role of storms, floods, and other physical processes in resuspending and transporting sediment along and across the shelf and upper slope have been undertaken in STRATAFORM over the past four years. As part of this component of STRATAFORM we have participated in these experiments and subsequent analysis of the results.

In this project our specific long-term goal is to understand the variability of the sediment response at the seafloor to bottom currents and stresses caused by physical oceanographic forcing. This work is accomplished through statistical and dynamical analyses of available field measurements of wave and current flows, sediment resuspension and concentration, and bottom sediment distributions.

OBJECTIVES

- Determine the role of internal waves and tides in affecting sedimentation on the upper slope and on the shelf in the STRATAFORM field area off northern California.
- Evaluate the importance of dense, near-bottom layers of suspended sediment for offshore sediment transport.
- Provide data input on physical and sediment parameters (currents, waves, suspended sediment concentrations) to shelf sediment transport models.
- Summarize the measurements and analysis of bottom boundary layer data collected with instrumented shelf tripods.

APPROACH

In our investigations of internal waves and tides we are using both historical and more recent CTD data collected by other STRATAFORM investigators to provide information on the nature and variability of the density field. We are also analyzing current, temperature and salinity data that has been obtained from sensors attached to a mooring in 450-m depth on the upper slope in the northern section of the STRATAFORM study area. This mooring has been maintained at this site by STRATAFORM investigators nearly continuously since September, 1995.We are also using for this analysis data

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collected by instrumentation mounted on bottom tripods that were deployed on the shelf in 50 to 60 m depths in the winters of 1996-97 and 1997-98.

We are utilizing discrete and time-series statistical analysis of primary physical and geological parameters (currents, waves, suspended sediment concentrations, bed elevation changes) and derived sediment transport parameters (wave and current shear velocities, bed stress, roughness scales). These statistics will be combined and evaluated to derive relationships for sediment response and physical forcing. A by-product of this work will be a data base for the measured and derived quantities.

We also are working with other investigators to estimate time-dependent sediment flux, particularly during energetic storms and river flood events. The significance of high concentration layers near the seafloor in the overall sediment transport conditions is a primary focus of this work.

WORK COMPLETED

- We have completed and reported on preliminary statistical analyses of current, temperature, and salinity data collected during 1995-1997 by sensors on the mooring on the upper slope (Cacchione, et al., 1998).

- Historical CTD profiles have been obtained and assembled into a data-base. These profiles and those that have been collected during STRATAFORM by other investigators are used to compute the stability frequency (Brunt-Vaisala frequency).

- In collaboration with Dr. Lincoln Pratson we have obtained detailed digital bathymetric data for the STRATAFORM study region (from multi-beam sonar data collected by L. Mayer, and from USGS data archives). A detailed bathymetric map and a bottom gradient map (derived from the bathymetry) for this region have been completed.

- We have computed and analyzed the energy characteristics for the internal tide and other higher frequency internal waves based on the density profiles, and have compared the slope of these characteristics with the bottom slopes thooroughout this region.

- Estimates of sediment transport during storms and flood events has been carried out with other investigators using bottom boundary layer measurements and shelf transport models (Cacchione, et al., 1999)

RESULTS

Preliminary analysis of the current, temperature and salinity time-series data from the mooring at 450-m depth suggests that the internal semi-diurnal tide is intensified near the seafloor, and accounts for about 75-80% of the energy in these records (Cacchione, et al., 1998). In addition, the first harmonic (M4) of the M2 internal tide was found to contain significant energy in the time-series of current and temperature data from the deepest sensors (at ~ 15 m above the bottom). Based on CTD profiles taken near the mooring site, we determined that the bottom slope between about 150 and 250 m depth is "critical" for the M2 internal tide (Cacchione, et al., 1998).

We have also produced a map showing the regions of the seafloor where the M2 and M4 internal tides can be expected to be "critical" (with L. Pratson; Cacchione, et al., 1998). This result indicates that significant portions of the mid-slope (depths of 400-700 m) and large areas near the shelf break (~150-200 m) are "critical" for the M2 internal tide. This potentially may explain the increased energy in the M2 tide near the seafloor, and the emergence of an energetic M4 tide near the bottom. We are continuing to analyze the implications of increased velocities due to topographic intensification of the internal tide in affecting sedimentation.

We have shown with others (R. Sternberg and A. Ogston) that significant seaward transport of fine-grained sediment on the inner to mid-shelf in the STRATAFORM occurs within a thin bottom layer. The values of the sediment concentrations within this layer equal or exceed values for fluid muds (>10 g/l). Other investigators (P. Traykovski and J. Lynch) also have evidence from acoustic data that fluid mud is found above the seabed in this region.

IMPACT/APPLICATIONS

If internal tides and other internal waves are found to actively resuspend bottom sediment or inhibit deposition of fine particles on shelves and slopes, we propose that the nature of slope sedimentation and slope gradients will be significantly influenced by these processes.

The interpretation that fluid mud formed following a period of high sediment discharge from the Eel River and large bed stresses has great implications for the amount of sediment transported on this shelf. If fluid mud forms on shelves that receive large amounts of sediment from coastal rivers, similar to that found off the Amazon river (Kineke and Sternberg, 1995; Cacchione, et al, 1995), then a major mechanism for shelf sediment transport will have been discovered.

RELATED PROJECTS

This project is closely related to other STRATAFORM projects which are involved measurements of sediment transport. These include projects by R. Sternberg and A. Ogston, U. of Washington, by L.D. Wright, VIMS, and by J. Lynch and J. Irish, WHOI. In addition, this project provides input to the modeling of shelf transport for STRATAFORM (Wiberg, et al., 1996). We are also working closely with Dr. L. Pratson in our analysis of internal tides and waves on the slope.

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